NERVE FIBERS SUPPLYING THE HORSE SWEAT GLAND

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It is a general belief that the sweat gland of the horse receives sympathetic innervation as in all other mammals. MUTO⁵⁾ found that the horse not only sweats in response to intravenously administered adrenaline, but reacts also to pilocarpine, and this is inhibited by atropine. His finding was confirmed by others and recently by EVANS and SMITH²⁾. He discovered, furthermore, that the sheep could be caused to sweat by adrenaline, but not by pilocarpine. In the evolutionary scale of the sweat apparatus, KUNO⁴⁾ therefore considered the horse to be placed between the sheep and man, in which the sweat gland in the general body skin responds to intravenous pilocarpine, but only to an intradermal injection of adrenaline.

However, from their results of study, EVANS and SMITH²⁾ have drawn a remarkable conclusion that the horse sweat gland discharges sweat only in response to an increase in the amount of adrenaline in the blood or to increased blood supply. They have gone so far as to suppose that there are in the horse no sudorific nerve fibers supplying the sweat glands. As there is no available information concerning the innervation of the sweat gland in the horse, we have taken up the problem and found that the secretory tubules of the gland have a moderate supply of nerve fibers, as will be described in the following lines.

MATERIALS AND METHODS

Sweat glands in the skin at the base of the ears, of the mesogastric region and the perineal region were the object of study. Skin materials obtained in a slaughterhouse and biopsy materials from an animal to be sacrificed for dissection by veterinary students were used. Small tissue pieces comprising sweat gland glomeruli were fixed in 10 to 20 per cent, neutralized formalin. They were cut into sections either directly by means of a freezing microtome or after being soaked in paraffin, and impregnated with silver following BIELSCHOWSKY's, SUZUKI's⁹⁾ and SETO's⁷⁾ methods and some of their modifications. Part of the fresh materials was stained by immersing it in a 0.02 per cent solution of methylene blue in 0.9 per cent salt solution and, after the stain was fixed in a solution of ammonium molybdate, was divided into frozen or paraffin sections.

Received for publication October 14, 1960

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RESULTS

The sweat gland of the horse is a tubular coil gland opening into the hair follicle. In the perineal region, the secretory portion of the gland forms a large, rather compact glomerulus in the corium. The secretory tubule is heavily pigmented with melanin granules. In the glands at the base of the ears and on the belly, the sweat glomerulus is composed of a less compactly wound and less pigmented tubule. The secretory tubule consists of a layer of gland cells, columnar to cuboidal in shape, and a myoepithelium, consisting of thin myoid cells with an elongated nucleus, and is invested by a basement membrane. For further details, the reader is referred to our previous paper¹¹). As regards the results of present study, no noticeable difference has been observed between the sweat glands in the different regions.

In preparations impregnated with silver, nerve fibers were shown as brown to black threads. Some of them ran in the connective tissue surrounding the secretory tubule and others in close proximity to this. The former were thicker than the latter, appeared flat in the form of a ribbon, and ran a wavy course (FIG. 1). The latter looked like tortuous or twisting, cylindrical threads. They proceeded very close to, or in contact with, the outer surface of the myoepithelium of the secretory tubule, gave off branches and appeared to form a reticulum (FIG. 2). Further observation showed that the thicker fibers ramified and provided the tortuous fibers. Both kinds of fibers contained argyrophile granules and at some places a Schwann's nucleus.

Staining with methylene blue afforded an excellent opportunity for detailed study of nerve fibers supplying the secretory tubule. Nerve fibers in the surrounding tissue were often seen to break up into branches and these, in turn, approaching the secretory tubule, to divide into twigs and form a network of fibers surrounding the tubule on the outer surface of the myoepithelium. It seemed to us very

FIG. 1. Showing a nerve fiber with a Schwann's nucleus (SN), which is ribbon-like in form and runs at a distance of a secretory tubule. SC....Nucleus of secretory cell. Mesogastric region. Seto's silver impregnation method. $\times 3,000$.

FIG. 2. Fine, tortuous nerve fibers form a terminal reticulum on the myoepithelium of a secretory tubule. ME... Nucleus of myoepithelial cell. Perineal region. Seto's method. $\times 3,000$.

FIG. 3. Showing nerve fibers and their terminal reticulum demonstrated by methylene-blue staining method. Thick, ribbon-like nerve fibers ramify into fine, tortuous fibers, which form a terminal reticulum (indicated by arrow) on the outer surface of the myoepithelium of secretory tubule. At the center of the figure, note fibrous myoepithelial cells arranged almost parallel to the long axis of the secretory tubule. Mesogastric region. $\times 700$.

likely that these fibers corresponded to the thin tortuous fibers found close to the myoepithelium in the silver impregnation slides. Part of a methylene-blue stained preparation is shown in a photomicrograph (FIG. 3).

DISCUSSION

Histological studies on the nerve supply to the sweat glands, conducted mainly in the eccrine glands of man, have resulted harmoniously in finding out a network of nerve fibers intimately surrounding the secretory tubule, which has differently been termed by different authors: the fundamental sympathetic plexus (BOEKE¹⁾), the terminal reticulum (JOHN³⁾, STÖHR⁸⁾) or the distal nervous syncytium (PRIETO and JABONERO⁶⁾). Recently, SUZUKI¹⁰⁾ has found a terminal reticulum well developed on the basement membrane investing the secretory tubule, from which nerve fibers pierce this membrane to reach both the periterminal reticulum on the myoepithelium and the interstitial cells interspersed among the secretory cells. It has been shown in the present study that in the horse a terminal reticulum composed of tortuous thread-like fibers is situated directly on the myoepithelium and these fibers are afforded by ramifications of thick, ribbon-like nerve fibers distributed in the connective tissue around the secretory tubule of sweat glomerulus.

EVANS and SMITH²⁾ have considered that the horse sweat glands respond only to certain concentrations of adrenaline in the blood or increased blood supply and even that any nervous action can in this regard be left out of consideration. Though their study is interesting and valuable, it still does not seem to eliminate the possibility of the occurrence in this animal of the sweating under nervous control. The present report on the presence of nerves supplying the sweat gland might indicate that further study is necessary on the physiology of sweating in this animal.

SUMMARY

Thick, ribbon-like nerve fibers are distributed in the connective tissue surrounding the secretory tubule of the horse sweat gland. They ramify and give rise to fine, tortuous fibers, which form a terminal reticulum on the outer surface of the myoepithelium of the secretory tubule.

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